Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

TEACHING PUPILS HOW TO SOLVE PROBLEMS IN ARITHMETIC

R. S. NEWCOMB
East Central State Teachers College, Ada, Oklahoma

It is the common knowledge of every teacher of arithmetic that the most difficult part of the subject is the securing of satisfactory results in the solution of problems. Practically all pupils have more or less difficulty in solving problems. Even those who have gained a comparatively high rate of speed and accuracy in the fundamental operations do not always succeed equally well in problem-solving. Psychological experimentation has shown that many of the difficulties encountered by pupils in problem-solving are due to wrong methods of attack. There are many different methods of procedure in the solution of any problem, but it stands to reason that there must be one best method. The method of procedure described in the following pages is an attempt to discover this best method.

The development of this method grew out of frequent requests from the Arithmetic Club of the State Teachers College at Ada, Oklahoma, that the department of mathematics offer some suggestions whereby more satisfactory results could be secured in the teaching of arithmetic. An examination of the various difficulties encountered by the teachers of arithmetic revealed the fact that the major difficulties were in connection with teaching pupils how to solve problems. A study of the difficulties described by the teachers and observed among pupils in the training school and a number of ward schools led to the question whether there might not be a few general principles applicable to the solution of practically all types of arithmetic problems.

In answering this question a consideration of the psychological basis of reasoning seemed to offer the most plausible solution. That reasoning is no longer regarded as a mysterious faculty of abstraction, but is rather in a very large measure subject to laws of habit much the same as other mental and physical activity, is at present a generally accepted fact. In this connection Dr. Thorndike makes the following statement:

> Reasoning or selective, inferential thinking is not at all opposed to or independent of the laws of habit, but really is their necessary result under the conditions imposed by man's nature and training. A closer examination of selective thinking will show that no principles beyond the laws of readiness, exercise, and effect are needed to explain it.[1]

In the pupil's work in the solution of problems it is possible for him to form careless, slipshod, and illogical habits of thinking on the one hand or careful, systematic, and logical habits on the other. If the teacher can control and direct the work of the pupil so that only habits of the second type are formed, much better results of a permanent nature may be expected from his work.

Some desirable habits by which it was thought the pupil might profit in solving problems are reading the problem over carefully and thoughtfully before attempting a solution, looking up the meaning of any unfamiliar word, analyzing and arranging in an orderly manner the data given, determining the precise data required, selecting in the proper order the various processes necessary to effect a solution, deciding beforehand a reasonable result to expect, and carefully checking or evaluating the final result secured.

In order that the pupils might form these habits, the plan of requiring each pupil to follow a definite procedure in each solution was decided upon. Accordingly, each pupil was required to solve a number of problems over a period of six weeks on a separate solution sheet. This solution sheet besides providing for the usual identification data reserved spaces for the following items: the statement of the problem, how to read a problem, the data given, the data required, the processes necessary to effect a solution, the approximate answer, the solution proper, and the checking of the result.

To make certain that the method was worth while twenty carefully prepared problems of graded difficulty were selected, and the pupils in two eighth-grade classes and two seventh-grade classes were required to solve them, one each day, in the suggested manner.

---

[1] E. L. Thorndike, *The Psychology of Arithmetic*, p. 190. New York: Macmillan Co., 1922.

The Stone Reasoning Test 2 was given as an initial measure and again at the end of six weeks after each of the twenty problems had been properly solved. To serve as a double check on the merits of the proposed method the Stone Reasoning Test 2 was given to one other class in each grade on the same days. The teachers of these classes knew nothing of the proposed method and continued teaching during the intervening six weeks in the usual manner. The results obtained in the four classes were taken as a fair indication of the merits of the proposed method.

An integral part of the method is the preliminary preparation of the class for the solution of the twenty problems in the manner desired and the careful oversight and help of the teacher during the period. Therefore, in order that the method might be properly followed by the four classes, the teachers were advised in brief as follows:

> It must be kept in mind that in order to reason properly about problems and to solve them with accuracy and facility the pupil must be able to
>
> 1. Understand each word in the problem
> 2. Read the problem intelligently
> 3. Add, subtract, multiply, and divide with speed and accuracy
> 4. Determine what is given in the problem
> 5. Determine the part required
> 6. Select the different processes to be used in the solution and the order in which these processes are to be used
> 7. Plan the solution wisely and systematically
> 8. Check readily

The instructions, in addition to including the ordinary routine directions with reference to carrying out the method, further emphasized the importance of considerable drill on the proper methods of reading and interpreting problems, determining what is given and required, organizing and planning a solution, and checking results. For the purposes of this paper it will be unnecessary to go into greater detail concerning the instruction other than the quoting of two of the closing paragraphs.

> A pupil who has difficulty with any of the problems may be shown how to solve them, but it is a better plan to have such a pupil tell what he thinks the problem means and how he would solve it. The difficulty may in that way be discovered by the teacher, and by skilful questioning she can lead the pupil to understand the problem and to select the right method of solution.

Since one of the chief aims of the study of arithmetic in the upper grades is exercising and developing the reasoning ability of the pupil, great care should be taken to see that he learns proper methods of attacking a problem and that he learns the most effective means of procedure in a solution. Careless, slipshod methods of attack plus unplanned, unorganized hit-or-miss methods of procedure will not produce good reasoners. Greater emphasis must be placed on the several elements of a solution as outlined if the end of upper-grade arithmetic is to be finally realized.

The following indicates the type of problem used and the preliminary work required of the pupil.

If a motor truck delivered 91 tons of coal in one day at a cost of $18.24, and a team and wagon delivered 40 tons in one day at a total cost of $15.84, find the amount saved on each ton by delivering with a motor truck.

Read the problem over carefully and thoughtfully.

Given: 91 tons
$18.24 cost by motor
40 tons
$15.84 cost by wagon
To find: Amount saved per ton
Processes: Division, division, subtraction
Approximate answer: 20 cents
Solution
Check

For convenience in the remainder of the discussion the four classes which were required to use the proposed method will be designated as the experiment classes, and the two classes which were taught in the usual manner but were given the Stone Reasoning Test 2 on the same days will be designated as the control classes. It is well to keep in mind that a very substantial improvement should be expected in each of the six classes since the pupils were given the same test on both dates and were consequently more familiar with the test the second time and also had the advantage of six weeks of additional school training. The merits of the proposed method are based largely on the greater improvement made by the experiment classes.

In making comparisons it is well to remember that the classes numbered 1, 2, and 3 were eighth-grade classes and those numbered 4, 5, and 6 were seventh-grade classes. According to Table I, the median speed of the eighth-grade class No. 1 increased 22 per cent in the period of six weeks, that of the eighth-grade class No. 3

increased 41 per cent, while the median speed of class No. 2, one of the control classes, increased only 12 per cent. The median speed of class No. 4 in the seventh grade increased 17 per cent, that of class No. 6 increased 15 per cent, while class No. 5, which was taught in the usual manner, shows an actual loss in speed of 2 per cent.

In accuracy a gain of 14 per cent in the median score of both class No. 1 and class No. 2 is noticed. This is considered a favorable showing for class No. 1 since the increase in speed made by this class was 10 per cent greater than that made by class No. 2. Class No. 3 shows no improvement in accuracy, but when it is recalled that this class made an increase in speed of 41 per cent it is gratifying that no loss in accuracy resulted. An increase of 10 per cent in accuracy was made by class No. 4 and losses of 9 per cent and 1 per cent by classes 5 and 6 respectively.

TABLE I

MEDIAN SCORES OF SIX CLASSES—STONE REASONING TEST 2*

CLASS	SPEED			ACCURACY		
	January 10	February 21	Percentage of Improvement	January 10	February 21	Percentage of Improvement
1	6.7	8.2	22	61.4	70.0	14
2	5.2	5.8	12	57.2	65.4	14
3	3.7	5.2	41	70.0	70.0	0
4	5.3	6.2	17	57.7	63.7	10
5	4.6	4.5	2	54.9	50.0	−9
6	4.0	4.6	15	62.0	61.1	−1

* Classes 2 and 5 were the control classes.

A more critical study of the results shown in Table I indicates that while an average gain of 5.1 per cent in speed and 2.9 per cent in accuracy is being made by the control classes, the experiment classes make an average gain of 22.8 per cent in speed and 5.5 per cent in accuracy.

An examination of the results in Table II reveals the fact that 75.2 per cent of the pupils enrolled in the four experiment classes made an improvement in speed; 53.3 per cent made an improvement in accuracy, and 47.6 per cent improved in both speed and accuracy. During the same period of time 61.3 per cent of the pupils enrolled in the two control classes showed an improvement in speed; 50.0 per cent showed an improvement in accuracy, and 32.3 per cent improved in both speed and accuracy. In other words, based on the percentage of pupils improving in the two groups, the experiment group showed a superiority over the control group of 13.9 per cent in speed, 3.3 per cent in accuracy, and 15.3 per cent in speed and accuracy combined.

TABLE II

NUMBER OF PUPILS IMPROVING IN SPEED AND ACCURACY IN THE SIX WEEKS' PERIOD—STONE REASONING TEST 2*

Class	Number in Class	Speed		Accuracy		Speed and Accuracy	
		Number	Per Cent	Number	Per Cent	Number	Per Cent
1........	31	22	71.0	18	58.1	16	51.6
2........	36	21	58.3	21	58.3	15	41.7
3........	14	13	92.9	7	50.0	7	50.0
4........	25	18	72.0	16	64.0	14	56.0
5........	26	17	65.4	10	38.5	5	19.2
6........	35	26	74.3	15	42.9	13	37.1

* Classes 2 and 5 were the control classes.

TABLE III

NUMBER OF PUPILS EQUALING OR EXCEEDING THE STANDARD SCORES IN SPEED AND ACCURACY*

Class	Speed		Accuracy	
	January 10	February 21	January 10	February 21
1....................	9	16	4	6
2....................	5	8	6	3
3....................	0	3	2	4
4....................	1	7	3	4
5....................	3	3	1	5
6....................	2	3	8	5

* Classes 2 and 5 were the control classes.

The results in Table III indicate that as a whole a larger percentage of the pupils of the experiment classes made records in the second test equal to or above the standard scores. Twenty-seven and six-tenths (27.6) per cent of the pupils enrolled in the experiment classes made scores in speed equal to or above the standard score in the second test, as compared with 17.7 per cent of the pupils enrolled in the control classes. The corresponding percentages of pupils making scores equal to or above the standard score in the initial test were 11.4 and 12.9 respectively. Thus it is seen that, although the scores of the pupils of the experiment classes were slightly lower in the beginning, in six weeks' time the percentage of increase in speed alone is practically four times that made by pupils in the control classes. In accuracy 16.2 per cent of the pupils in the experiment classes and 11.3 per cent of the pupils in the control classes made scores equal to or above the standard scores in the first test, while in the second test 18.1 per cent of the pupils in the experiment classes and 12.9 per cent of the pupils in the control classes made scores equal to or above the standard.

TABLE IV

SCORES OF A GROUP OF FIFTEEN PUPILS SELECTED FROM ONE OF THE EXPERIMENT CLASSES (CLASS 1)

Pupil	Speed		Accuracy	
	January 10	February 21	January 10	February 21
1	9.3	10.7	60	70
2	9.7	12.1	66	100
3	6.9	10.7	62	70
4	6.9	6.8	62.	100
5	4.9	8.3	42	67
6	10.3	12.7	63	80
7	4.7	10.1	33	75
8	6.1	7.5	57	66
9	9.3	8.5	87	100
10	10.9	13.1	100	88
11	8.1	13.9	100	90
12	3.7	9.7	33	88
13	3.7	7.9	33	75
14	7.1	9.5	83	84
15	9.9	13.1	63	81

The final results secured through the experiment classes, when examined from any angle, show appreciable superiority over the records made by the pupils of the control classes.

While the method has been used in altogether too few classes to warrant a general acceptance of the plan, the results secured are sufficient to commend it for trial to all teachers who are experiencing difficulties in teaching pupils how to solve problems.